Chironomid midges as a cause of allergy in the Sudan

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Summary

Hypersensitivity to Chironomidae (non-biting midges) has been a problem in the Sudan since about 1927 and appears to be due to increased breeding of a single chironomid species, Cladotanytarsus lewisi (Freeman). Mass emergence of the midges is thought to be related to the larval diet of algae and diatoms, the numbers of which are greatly enhanced by the retention of plant nutrients in lacustrine conditions resulting from interruption to the natural flow of the Nile by the construction of dams.

Immunological studies in allergic individuals using an allergen extract prepared from C. lewisi indicate that the concentration of specific immunoglobulin E ("allergic antibody") directed against C. lewisi is raised in patients with established hypersensitivity to the mridge but not in control subjects. The concentration of specific IgE is also related to the severity of clinical symptoms. These results indicate that this widespread and important "man made" hypersensitivity in the Sudan has the features of well recognized immediate-type allergy commonly associated with pollens and other air-borne allergens.

Introduction

Chironomidae (non-biting midges) have been associated for many years with allergic symptoms in people living close to the Nile in Northern and Central Sudan. In the Sudan Medical Service Annual Report (1951) Kirk reported that a number of patients with bronchial asthma gave a very high proportion of strongly positive skin reactions when tested with crude extracts of antigen prepared from midges. In the following year (1952) the Report stated that there was strong circumstantial evidence that chironomids were a common cause of hay fever, asthma and other allergic complaints.

L. Lewis (1956) proposed that the Chironomidae should be referred to as "green nimrit" to distinguish them in common parlance from the common blood-sucking "grey nimrit", Simulium griseum Bebecr (Simulididae), which are troublesome near rapid stretches of the Nile, particularly in the Dongola region of Northern Sudan. In reviewing the history of the chironomid problem, Lewis (1956) noted that Chironomidae were reported as intermittently troublesome at Khartoum from about 1927, while in the north at Wadi Halfa asthma problems, believed to be associated with exposure to Chironomidae, were so severe that hospital camps were erected at some distance from the river during the winter season of peak emergence of midges. These peak emergences which reach plague proportions in some years occur in the period of low discharge of the Nile, in the months following the late summer/autumn rains. The number of people who are hypersensitive is uncertain, but our experience and those of others suggests there are probably several thousand, particularly close to dams on the Blue Nile (Sennar and Roseires), on the White Nile (Jebel Auliya) and extending to the Khartoum area. The problem also occurs at Wadi Halfa and probably extends to Upper Egypt near Lake Nasser (Satti & Abdel Nur, 1974). In contrast, people living far from the Nile basin are not affected nor are those living on the Nile where the flow is not affected by the working of dams. The circumstantial evidence that the alteration of the hydrology of the Nile is responsible for the greatly increased numbers of Chironomidae is strong and is discussed below.

Since a single chironomid species, Cladotanytarsus lewisi (Freeman), appears to be a major allergen in Northern Sudan as a causative agent in allergic rhinitis and/or bronchial asthma, it seemed important to re-investigate this problem particu-
larly in regard to the interrelationships between the entomological, immunological and epidemiological aspects. Our eventual aim is chemically to characterize and localize the allergen(s), to understand the reasons for the dominance of this species of Chironomidae, to establish the true extent of the clinical problem and to develop therapeutic manoeuvres accordingly.

Entomological Aspects
Samples of midges believed to be responsible for hypersensitive reaction in the Sudan have always been found to contain a high proportion of a species FREEMAN (1950) described as Tanytarsus (Gladotanytarsus) lewisi, now known as Gladotanytarsus lewisi (Freeman). This species is known only with certainty from the Blue and White Niles near Khartoum, and from Wadi Halfa in North Sudan, although a species of Gladotanytarsus identified as lewisi has been collected from Lake Victoria (Uganda) (McLachlan in litt. to Hutson).

In describing the biology of C. lewisi and some other Nilotic Chironomidae, LEWIS (1957) noted the typical aquatic development of the immature stages with increasing numbers of larvae and pupae entering the water body from the benthos at night as drift. LEWIS et al. (1954) described the monitoring by light trapping of daily numbers of small chironomids using the methods of GRINDLEY (1952). What appeared to be random daily fluctuations in the numbers of midges caught at light traps on the south side of the Blue Nile at Khartoum may have been related to variations of the prevailing north wind, but to neither air nor water temperature.

Control of the aquatic larval Chironomidae was attempted by BROWN et al. (1961) who claimed DDT and DDD to be effective larvicides, but the expense of spraying large stretches of the Nile, in addition to fish mortality and the broader ecological damage to large stretches of the Nile, persuaded the World Health Organization that while biological control might be random daily fluctuations in the numbers of midges during these two months. During this time the severity of bronchial asthma and allergic rhinitis was low. The highest nightly catch reported was 430,000 midges per trap per night, and this minimal and the numbers of midges were low. The day-to-day changes in numbers of these "other" species showed the same pattern as those of Gladotanytarsus lewisi, but the larger the total catch, the greater was the proportion of C. lewisi. The number of C. lewisi and "other Chironomidae" was calculated from the dried weight, the mean weight of C. lewisi and "others", and the percentage composition of subsamples of each night's catch.

Patient "symptom scores" were compared with fluctuations in daily numbers of midges during these two months. During this time the severity of bronchial asthma and allergic rhinitis was minimal and the numbers of midges were low. The highest nightly catch reported was 430,000 individuals in a sample of 98% C. lewisi, but was not associated with any increase in patient symptom scores. However, an emergence in late December, although not quantitatively sampled, was estimated to contain numbers considerably in excess of half a million midges with over 99% C. lewisi, and was clearly associated with severe bronchial asthma and allergic rhinitis and other signs and symptoms of immediate-type hypersensitivity.

Ecology
LEWIS (1956, 1957) discussed the biology of C. lewisi and suggested that the problem of mass emergence was associated with hydrological changes due to the construction of dams, particularly the development of more lacustrine (lake-like) conditions. The construction of the Sennar Dam on the Blue Nile coincided quite closely with the development of large numbers of chironomid midges, but there is a period of some 30 years after the construction of the Assuan Dam before the problem was reported at Wadi Halfa on the lake formed behind this dam. Although the possible relationship between impoundment of the Nile and mass emergence of midges has been suggested for many years, the biological mechanisms are not understood.

Examination of the gut contents of larval C. lewisi in January 1980 showed that Melosira granulata, a diatom, and Anabaena flos-aquae f. sphaericus, were dominant in the gut, with smaller numbers of Cymbella sp. The former two species are dominant in the phytoplankton development
after the turbid waters of the flood have cleared (see reviews by Hammerton, Talling and Rzoska in Rzoska, 1976). It appears that these diatoms and algae are available to benthic organisms (such as Chironomid larvae) either through the natural circulation of phytoplankton or through adventitious (attached) stages in the development. Talling (in Rzoska, 1976) reviewed studies on seasonal and temporal phytoplankton development at Jebel Auliya and on the Nile at Khartoum in lacustrine conditions caused by the impoundment or seasonal obstruction of the Blue Nile by the White Nile. It appears that a massive increase in phytoplankton takes place close to the dam in the months following the summer rains and that these greater numbers of phytoplankton are associated with an increase in temperature, pH and, most importantly, plant nutrients (Saed, 1976). Nutrients of particular importance appear to be nitrate and phosphorous, the levels of which are maximal in November and decrease as maximal algal growth takes place. It is suggested that the concentration of these nutrients is a limiting factor in phytoplankton growth (Saed, 1976; Talling in Rzoska, 1976). Thus, it is our impression that the phytoplankton development commences slightly before the first recorded emergence of C. lewisi, whereas the final emergence parallels quite closely the rapid fall in phytoplankton levels. In order to gain further information on the reasons for these fluctuations studies are currently underway to test the hypotheses: (i) that the changes in phytoplankton levels are paralleled by changes in numbers of adventitious diatoms and algae available as food for larval Chironomidae, and (ii) that numbers of C. lewisi larvae are correlated to adventitious algal and diatom numbers.

Thus the postulate is briefly as follows. C. lewisi, with a presumed short life-cycle, is able to respond rapidly to increased larval food made available by the elevated plant nutrient levels following the annual floods. The effect of the slowing of the natural flow of the Nile by the construction of the dam allows retention of plant nutrients and the lacustrine conditions permit massive development of phytoplankton after the turbidity decreases. Cessation of the mass emergence of Chironomidae results from diminution of algal and diatom levels when one of the plant nutrients reaches a limiting level due to incorporation into the sediment, into fish, or loss to the system through the emergence of adult insects. The implications of these relationships are that altered hydrological regimes may prove more effective than chemical means in controlling midge numbers.

Immunological Aspects

In 1978 a sample of midges was sent to the British Museum (Natural History) for identification. It was found to contain over 99% Cladotanytarsus lewisi (Freeman), a species previously implicated in causing allergic response in the Sudan (Freeman, 1950; Lewis, 1956, 1957). This "virtually pure" sample of C. lewisi was used in the preparation of a "green nimitti" antigen (Kay et al., 1978). It was established that sera from Sudanese with bronchial asthma and/or rhinitis associated with exposure to "green nimitti", although in 17 cases it was equivocal. All patients were skin ("prick") tested using a "green nimitti" extract (Kay et al., 1978), and graded I-V according to the severity of the skin test response (see reviews by Hammerton, Talling and Rzoska in Rzoska, 1976). Thus, it is our impression that the phytoplankton development commences slightly before the first recorded emergence of C. lewisi, whereas the final emergence parallels quite closely the rapid fall in phytoplankton levels. In order to gain further information on the reasons for these fluctuations studies are currently underway to test the hypotheses: (i) that the changes in phytoplankton levels are paralleled by changes in numbers of adventitious diatoms and algae available as food for larval Chironomidae, and (ii) that numbers of C. lewisi larvae are correlated to adventitious algal and diatom numbers.

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The results of the RAST can be summarized as follows: Sera from 104 Sudanese individuals, assessed as hypersensitive to "green nimitti" by a positive skin test and/or clinical history, were studied. 80 patients were from the Jebel Auliya district, 18 from the Khartoum district and six were asymptomatic skin test positive volunteers. The 98 patients with symptoms all gave a history of bronchial asthma and/or rhinitis associated with exposure to "green nimitti", although in 17 cases it was equivocal. All patients were skin ("prick") tested using a "green nimitti" extract (Kay et al., 1978), and graded I-V according to the severity of the skin test response (see reviews by Hammerton, Talling and Rzoska in Rzoska, 1976). Thus, it is our impression that the phytoplankton development commences slightly before the first recorded emergence of C. lewisi, whereas the final emergence parallels quite closely the rapid fall in phytoplankton levels. In order to gain further information on the reasons for these fluctuations studies are currently underway to test the hypotheses: (i) that the changes in phytoplankton levels are paralleled by changes in numbers of adventitious diatoms and algae available as food for larval Chironomidae, and (ii) that numbers of C. lewisi larvae are correlated to adventitious algal and diatom numbers.

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